R & D facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Chemistry and Surface Science

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Hydrogen Separation Facilities

Background

The production of hydrogen from fossil fuels, such as by coal gasification, is viewed as a pathway to a hydrogen economy based on renewables. The NETL Hydrogen Separation Group investigates, evaluates, and develops hydrogen separation membranes and materials in order to enhance hydrogen production from fossil fuels and decrease costs.

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R&D

The Hydrogen Separation Group conducts research in four main areas:

- **Membrane Materials Research** - develop basic materials information for producing suitable membranes for separating hydrogen at realistic conditions.
- **Membrane Performance Testing** - characterize the performance of promising novel membranes using continuous gas feed streams and conditions representative of industrial processes with regard to flux, selectivity, durability, and impurity resistance.
- **Water Gas Shift Membrane Reactor Development** - evaluate kinetics and membrane flux in developing a membrane reactor for enhancing the water-gas shift reaction at high temperature and pressure with no added catalyst.
- **Advanced Separation Science** - explore new concepts and conduct fundamental studies to reduce hydrogen production costs (e.g., carbon dioxide selective membranes and computational chemistry of hydrogen transport and of sulfur poisoning).

State-of-the-Art Facilities

- **Three Hydrogen Membrane Test (HMT) Units:** These units provide the unique capability of high-pressure, high-temperature hydrogen membrane flux measurements at conditions of up to 1000 psi at 900°C. The units can accommodate membrane sizes up to one inch in diameter and up to six inches in length in both disk and tubular configurations, with process gas flow rates up to 20 L/min. In addition, the HMT units have the flexibility to be used for both membrane separation testing and membrane reactor testing.
  - HMT -1: dedicated to studies that utilize sulfur-laden, “dirty” gas streams without concerns about cross-contamination with clean gases.
  - HMT -2: used as a “clean” system for testing with gas mixtures containing no sulfur compounds.
  - HMT-3: optimized for testing membrane reactor systems, such as for the WGS reaction, but also can be used for membrane separation testing.

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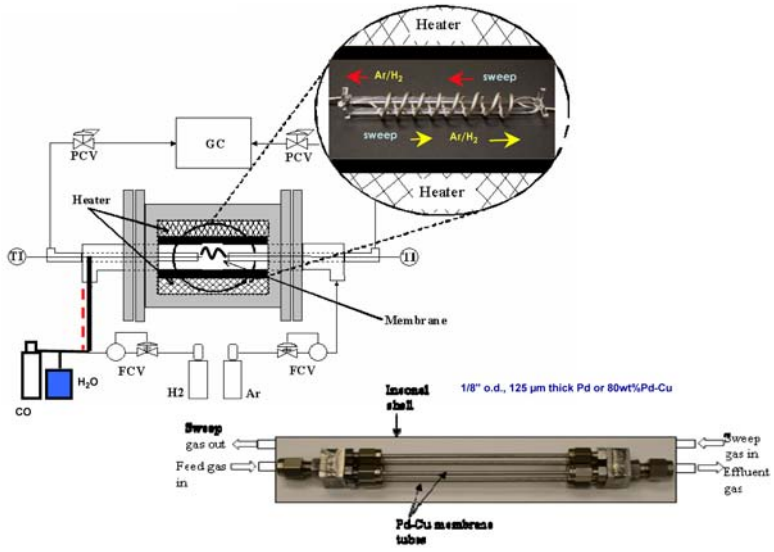
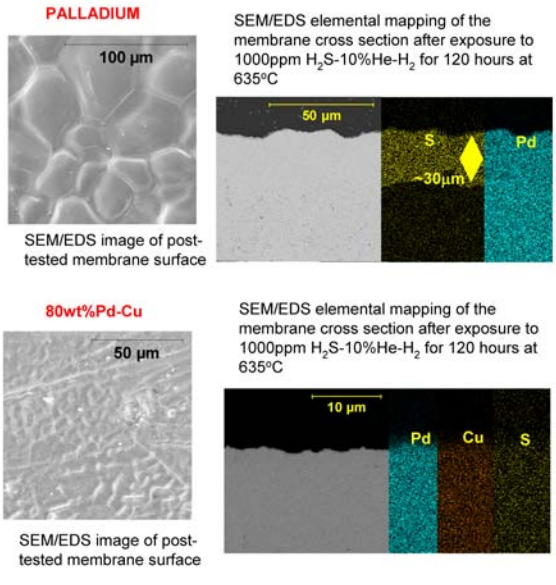
- **Membrane Screening Systems:** Laboratory Membrane Screening Systems (MSS) are used for small-scale, low-pressure analysis of membrane permeation under different environments, or for conditioning materials prior to subsequent characterization. For example, it allows for short-term testing of membrane materials with different sulfur-containing gas mixtures at varying temperatures.
- **Materials Lab:** Membrane fabrication capabilities include a well-equipped laboratory for inorganic materials preparation. Equipment available for alloy fabrication includes high temperature, controlled atmosphere furnaces, precision TIG welder, arc welder, hydraulic presses, high temperature-corrosion resistant TGA, and cold plasma sputter coaters. Machine shop facilities are also available.
- **ASPEX SEM:** An Aspex PSEM 2000 scanning electron microscope equipped with an energy dispersive x-ray detector (EDS) is used for membrane and materials characterization. Changes in membrane morphology, element migration, layer thickness, and pore size are among the characteristics studied.
- **PANalytical XRD:** A PANalytical X-Ray Diffraction instrument with a hot stage, cold stage, and high-speed detector is used for determining and observing membrane material crystal structure under realistic membrane conditions.
- **Other Analytical Capabilities** at NETL that may be utilized for membrane and materials characterization include:
  - Multitechnique Surface Analysis System (STM, AFM, XPS, AUGER, ISS, LEED)
  - X-ray photoelectron spectroscopy instrument with small spot capability
  - Atomic force microscope
  - Infrared Reflection Absorption Spectroscopy
  - FTIR and Raman spectroscopy (both with microscopes)
  - BET surface area analysis
  - Chemisorption and physisorption analyzer



Tubular Membrane Reactor Assembly



Results of 5-day Exposure to H_2S at 635 °C (Feed composition: 1000ppm H_2S-10% He-balance H_2)